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Growth of seashore paspalum, (*Paspalum vaginatum* L) in soil contaminated with crude petroleum oil

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ABSTRACT: The effect of crude oil contaminated soil on the growth of seashore Paspalum (*Paspalum vaginatum* .) seedlings was investigated. Plants were grown in soil containing different concentrations: 0%, 0.5%, 1.0%, 2.0% and 3% (w/w) of Abura crude petroleum oil. Growth parameter such as shoot number, shoot length, leaf area and biomass accumulation were evaluated. The results showed that crude oil imposed physiological stress in the seedlings. There was a dose response decline in all the growth attributes examined. There was also a significant difference in plant growth with respect to time of crude oil application. At the highest applied concentration(3 % [w/w]), plants grown in soil previously contaminated with petroleum oil showed about 50 % reduction in biomass accumulation when compared with the uncontaminated control whereas established plants post -treated with crude petroleum oil showed a 30% reduction. There was no mortality at any of the crude oil concentrations to which to plant was exposed. The experiment demonstrated the potential of using *Paspalum vaginatum* for phytoremediation. @ JASEM

Keywords: petroleum, oil, pollution, phytoremediation, wetland, mangrove, *Paspalum vaginatum*

Mangroves are an important part of estuarine and coastal ecosystems. A significant amount of petroleum oil is refined, stored, or transported through the mangrove ecosystem in Nigeria and as a result, the risk of an oil spill affecting this important ecosystem is high. Mangroves are very important source of natural resources upon which many rural economies and entire societies depend in Nigeria. They perform very important functions such as the supply goods and services that have economic and ecological values (Mitsch & Gosselink, 1993). Coastal environments in Nigeria are areas of intensive petroleum exploration, production, transportation, and refining. Oil spillages are frequently reported in Nigeria due to blowouts from oil wells, leakages of oil pipelines and oil well heads, equipment failure during oil production and transportation (Nwilo,1998). Oil spills both off shore and on-shore, may, via tidal effect, move to intertidal areas, especially the mangrove zone and cause great damage. Many workers have documented the effects of oil spillage in temperate regions (Mendelssohn *et al*., 1990; Pezeshk *et al*, 2000). Comparative data for tropical wetlands are scarce(Bamdele, 2008).

Ecotoxicity of hydrocarbons is highly variable, depending on their type and concentration, exposure time, state, environmental conditions and the sensitivity of affected species. The ecological impacts of oil on specific habitats has been studied by many authors, and clear differences are observed between sensitive taxa, Although massive oil spills are the most visible form of oil pollution, less dramatic forms –e.g. due to loading/unloading operations, refinery waste, urban runoff are common In Nigeria, data describing dose-response relationship of plants to oil and which document their oil tolerance limits are few . Lin and Mendelssohn, (1998) demonstrated the relative tolerance of *Spartina alterniflora* to crude oil and the use of the plant for phytoremediation of oil contaminated sediment. Phytoremediation is one of the in situ methods for treating oil contaminated soil and is especially good for wetlands since it is less intrusive than conventional mechanical methods (Merkl *et al*., 2004; Rivera-Cruz, 2004). There is need to characterize the sensitivity of Nigerian flora to crude oil and its refined products. This will form part of the necessary data base which can be used during environmental sensitivity index mapping, environmental audit and environmental impact assessment studies (Gundlach and. Hayes, 1978). The objectives of this work were to determine: (i) the sensitivity of *Paspalum vaginatum* to crude petroleum oil and (ii) whether *Paspalum vaginatum* transplants can potentially be used for revegetating oil contaminated sites in wetland environments.

MATERIALS AND METHODS

The crude oil was the Abura well was obtained from the Nigerian Petroleum Development Company (NPDC) Nigeria Ltd., Warri, Nigeria. Soil was collected from a brackish marsh in Warri, Delta State. The soil was homogenized. The original rhizomes and roots were removed during mixing. Abura crude oil was applied at concentration of 0, 0.5, 1, 2 and 3 % (w/w). The oil was introduced by pouring the appropriate amounts slowly from a beaker into the polythene bags containing already established seedlings. In a second experiment, crude oil was pre-mixed with the sediment to give the same concentrations as in experiment 1. The soil was placed in polythene bags and three rhizome fragments of *P vaginatum* were transplanted into each bag. In each experiment, the treatments were replicated four times. The plants were watered to field capacity on a regular basis. The experiments

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were terminated after six weeks. The shoot length was determined by measuring from the soil level to the terminal bud. Leaf area was determined using the method of Eze (1965). At final harvest, the plants were separated into leaf, root and stem. After determining the fresh weight on a Metler E 200 electronic balance, the plants were dried to constant weight at 80 °C for 24hrs in an oven. The dry weight was subsequently determined on a Metler balance. The data was analysed using the method described by Field (2005).

RESULTS AND DISCUSSION

Fig. 1 shows the effect of crude petroleum oil on the shoot length of *Paspalum vagnum.* There was a dose dependent decline in shoot length as a result of increasing amount of crude oil in the substrate in both pre-treated and post-treated plants. There was about 50% decline in shoot length at the highest applied

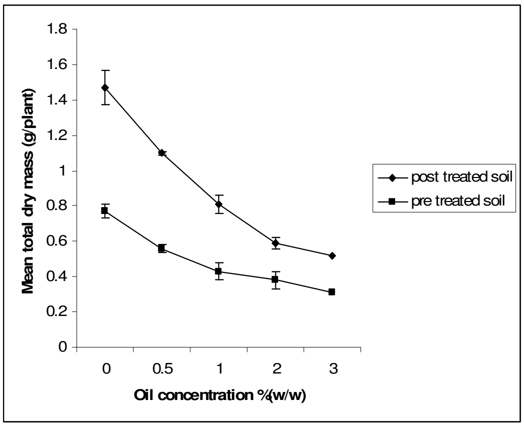

Fig. 1: Effect of crude oil pollution on total dry mass in *Paspalum vaginatum.* Results are means of 4 replicates. ± standard error.

Some studies show no impact of oil to wetland plants.. For example, *Spartina alterniflora* was unaffected by the application of up to 8 1 m^{-2} of Louisiana crude oil to field plots, with residual oil concentration in the soil up to 50 mg g- 1 (Delaune *et al.,* 1979). In other cases, petroleum hydrocarbons even stimulated the growth of this species (Li *et al.,* 1990). However, Alexander and Webb (1987) stated that oil concentrations in the soil greater than 10.5 mg g^{-1} caused decreased live stem density of *Spartina alterniflora* and led to long-term impacts. Mendelssohn *et al.* (1990) reported that about 0.28 1 m $^{-2}$ of crude oil, which coated the above-ground vegetation, caused a 64% reduction in live vegetation cover of *Spartina patens.*

concentration when compared with the un-contaminated soil. Generally, pos-treated plants had longer shoot lengths at all oil dosages in comparison with plants grown in oil pre-treated substrate. In Fig 1 the number of shoot per pot was also reduced with increasing oil concentration. While 8 and 6 tillers were formed in the post-treated and pretreated controls, plants subjected to the highest concentration 3 % (w/w) have an average of 4 tillers per pot in under both experiments. The present results show a progressive decline in the growth of *Paspalum vaginatum* subjected to crude oil pollution. The degree of oil impact depends upon a number of abiotic and biotic factors including the type and amount of oil, the plant species and extent of oil coverage, the season of the spill, the weather conditions at the time of spillage, and soil composition (Alexander and Webb, 1985, 1987; Mendelssohn *et al.,* 1990)

The leaf area of *Paspalum vaginatum* was reduced with increasing level of oil the substrate in both oil pre-treated and post- treated experiments. Oil application resulted in progressive decline in dry weight in both oil pre-treated and post-treated experiments. At the highest applied concentration(3 % [w/w]), plants grown in soil previously contaminated with petroleum oil showed about 50 % reduction in biomass accumulation when compared with the uncontaminated control whereas established plants post -treated with crude petroleum oil showed about 30% reduction.

The oil resistance of *Paspalum vaginatum* shown in this study, even up to 3 % (w/w), suggests the potential use of *P vaginatum* in oil-contaminated sites, either for protecting sediment from erosion, enhancing habitat restoration or accelerating oil degradation by generating a more aerobic soil environment. The survival of plants transplanted into soil previously contaminated with crude petroleum oil further showed the phytoremediation potential of *P vaginatum.* Grasses are often planted in tandem with trees at sites with organic contaminants as the primary remediation method. They provide many fine roots in the surface soil, which are effective at binding and transforming hydrophobic contaminants. Living plants have extensive root systems that help to bring microbes, nutrients, and contaminants into contact with each other (Bank *et al,* 2006*;* Keller *et al,* 2008). Thus, the presence of plants in contaminated soils greatly increases the volume of soil in which active microbial degradation can be stimulated. Several studies have shown the rhizophere effect in phytoremediation of PHCs. Gunther *et al*. (1996) found higher microbial numbers and activity coupled with increased degradation in hydrocarbon- contaminated soil planted to *Lolium perene* compared to unvegetated soil. They opined that plant roots stimulated microbes, which enhanced the degradation of hydrocarbons. Jordahl *et a.l* (2002) reported that microbes capable of degrading BTEX were significantly more abundant in the rhizosphere of *Populus deltoids* than in the bulk soil. Nichols *et al* . (2008) found higher numbers of organic chemical degraders in rhzosphere and contaminated soils compared to bulk and uncontaminated soils, respectively. One of the most important roles played by plants in rhizosphere biodegradation is the and release of root exudates that induce the rhizosphere (Kordel *et a*l, 1997). *Paspalum vaginatum* is a dominant mangrove grass in coastal swamps in West Africa and America. In conclusion, the study has shown that increasing concentration of oil in the substrate led to a progressive decrease in the growth of *Paspalum vaginatum*. Documentation of its growth response to crude oil and determination of its phytoremediation effectiveness has potentially widespread application.

Table 1: Effect of crude oil pollution on shoot length in *Paspalum vaginatum.* Results are means of 4 replicates. ± standard error.

Oil concentration % (w/w)	Shoot length (cm)	
	Paspalum planted before oil application	Paspalum planted in oil treated soil
0.00	33.50 ± 1.15 a	25.01 ± 1.05a
0.5	32.17 ± 0.85a	22.5 ± 1.90a
1.0	31.50 ± 0.88a	18.33 ± 0.40b
2.0	21.67± 1.46b	12.83 ± 0.17c
3.0	19.67 ± 98b -	11.67 ± 0.93c

Table 2. Effect of crude oil pollution on shoot number in *Paspalum vaginatum.* Results are means of 4 replicates. ± standard error.

Oil concentration % (w/w)	Mean shoot number/pot	
	Paspalum planted before oil application	Paspalum planted in oil treated soil
0.00	8.2± 4.5a	6.3 ± 0.5a
0.5	7.2 ± 1.4a	5.2 ± 0.2b
1.0	4.5 ± 1.4b	4.5 ± 0.4c
2.0	5.3 ± 1.4b	4.2 ± 0.3c
3.0	4.1 ± 1.3c	4.3± 0.6c

Table 3. Effect of crude oil pollution on leaf area in *Paspalum vaginatum.* Results are means of 4 replicates. ± standard error.

Oi conc. % (w/w)	Total leaf area (cm^2/plant)	
	Paspalum planted before oil application	Paspalum planted in oil treated soil
0.00	105.74 ± 4.54a	93.55 ± 0.52a
0.5	62.93 ± 1.48b	48.64 ± 0.86b
1.0	39.53 ± 1.44c	24.92 ± 0.42c
2.0	27.33 ± 1.95d	21.60 ± 0.33d
3.0	20.54 ± 1.12e	16.46 ± 0.97e

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